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(54) Electronic lock and key

(57) The key (1) is provided with a key-code setting means (2) in which a key-code is stored, while the lock is provided with a lock-code setting means (2a) in which a lock-code is stored. When the key (1) is inserted into the lock, if the key-code coincides with the lock-code, the lock will be unlocked. The key (1) and the lock can be provided with *n* code setting means, and one or more of the lock-code setting means (2a) can be selectively disabled, thus giving a plurality of different combinations (by 21-24). Accordingly, the user can use a single key (1) to unlock a plurality of different locks. The key-code and the lock-code depend on the state of switch units in the key-code setting means (21-24) and lock-code setting means (21a-24a).

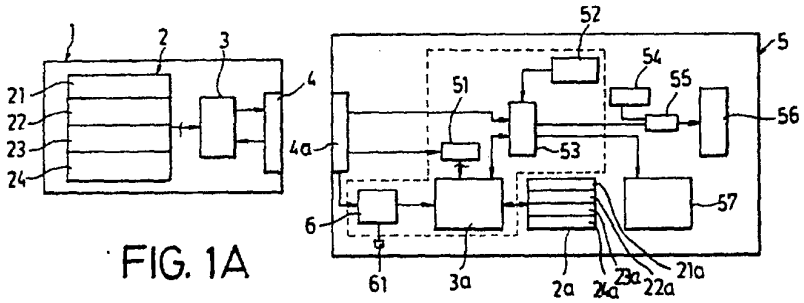

FIG. 1A

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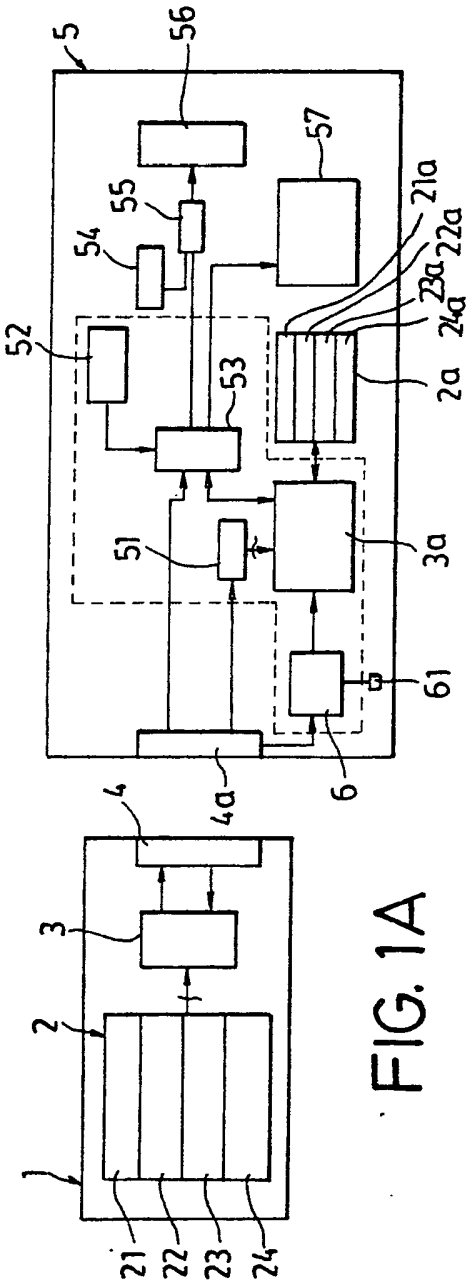
5
56
57
55
54
52
53
21a
22a
23a
24a
2a
3a
51
61
6
4a
4
3
2
1
21
22
23
24

FIG. 1A

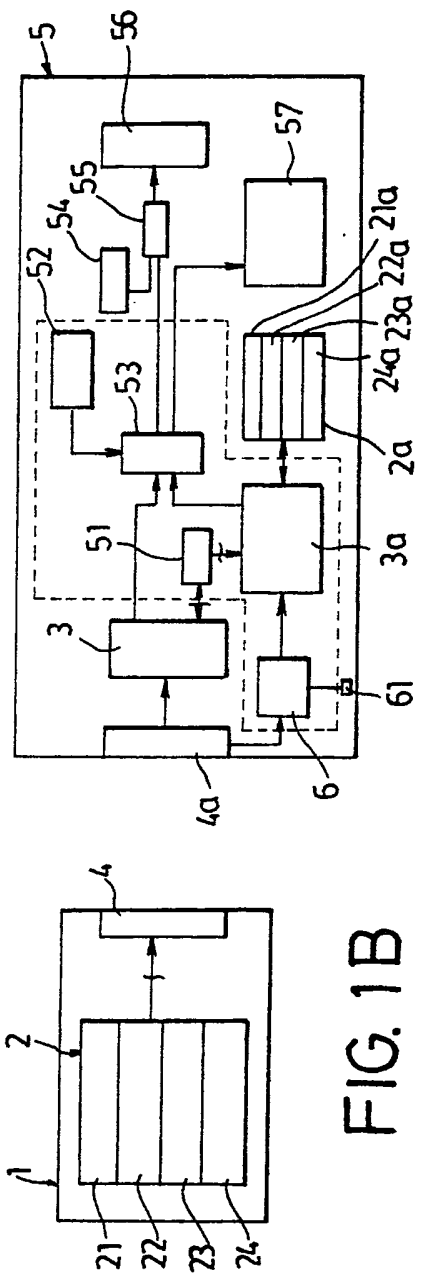
5
56
57
55
54
52
53
21a
22a
23a
24a
2a
3a
51
3
61
6
4a
4
2
1
21
22
23
24

FIG. 1B

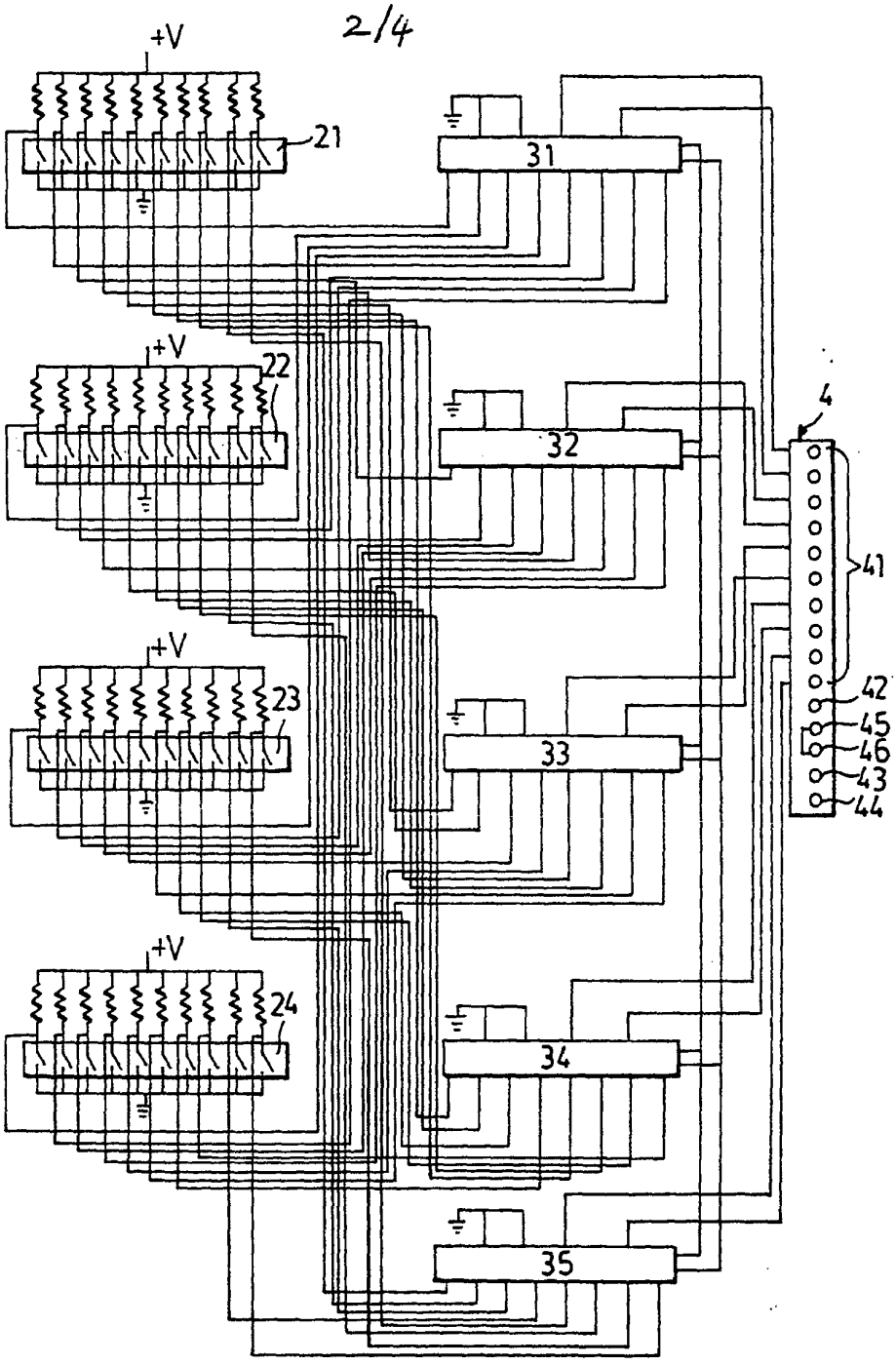

FIG. 2

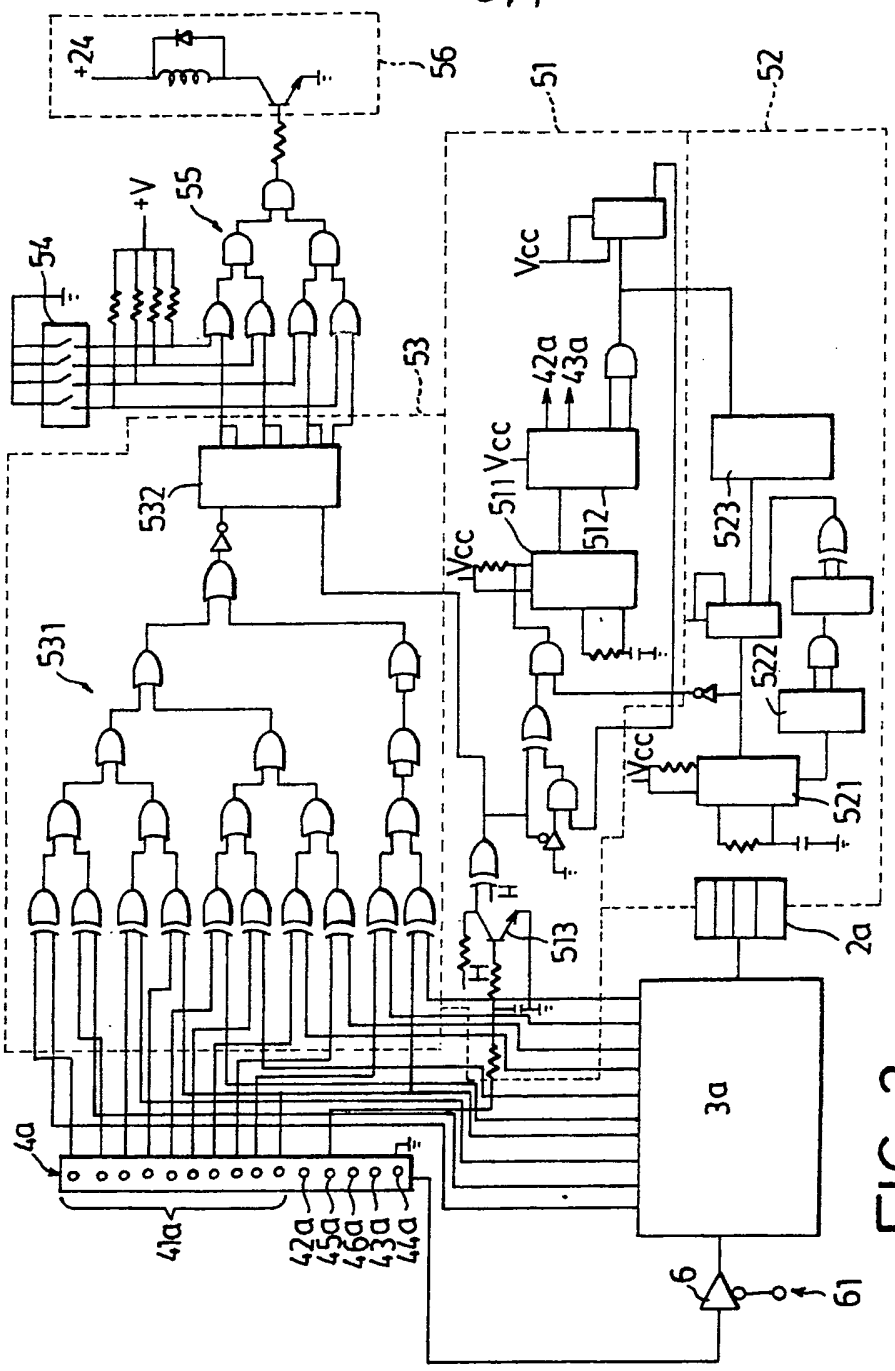
+24
56
51
52
+V
55
54
53
Vcc
42a
43a
511
Vcc
512
532
523
Vcc
531
522
521
513
2a
3a
4a
41a
42a
45a
46a
43a
44a
6
61

FIG. 3

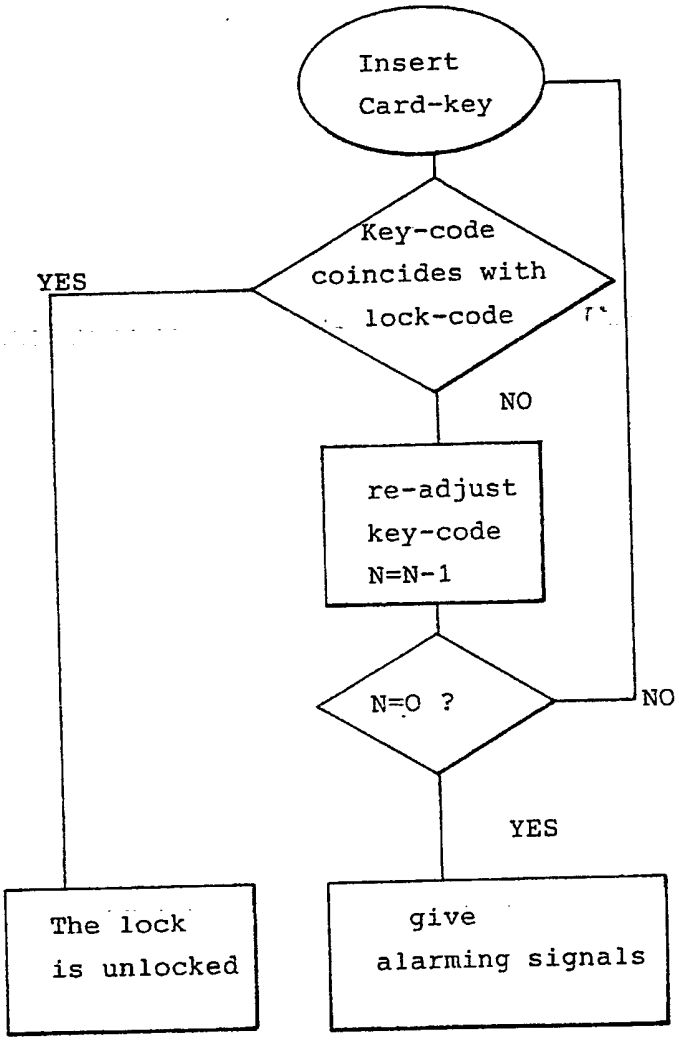
Insert
Card-key
Key-code
coincides with
lock-code
YES
NO
re-adjust
key-code
N=N-1
N=O ?
NO
YES
The lock
is unlocked
give
alarming signals

FIG. 4

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TITLE: A KEY AND THE CONTROL CIRCUIT FOR THE LOCK OF THE KEY

The present invention relates to a card key and the control circuit for its corresponding lock.

According to the present invention, the card key has a preset code (hereinafter referred to as "key-code"). Correspondingly, there is also a preset code in the control circuit (hereinafter referred to as "lock-code"). When the card key is inserted into the lock, if the key-code coincides with the lock-code, the lock can be unlocked.

According to another feature of this invention, the card key can be provided with a plurality of (for example, four) different key-codes, which respectively correspond to the lock-code of four different locks (each having a different lock-code). For example, the key can have four key codes 12, 45, 79 and 63.

According to still another feature of this invention, if a key is provided with a plurality of (for example four) key-codes, these codes can be combined to form a single code. For example, if it has four key-codes, say 12, 45, 79, 63 to unlock four different locks with code 12, 45, 79 and 63, the four codes can also be combined to give a single, more complicated code 12457963 (for convenient sake, this combination of code is hereinafter referred to as "total combined code"), to unlock a lock with the lock-

code 12457963. This can greatly increase the safety of the lock.

According to a further feature of this invention the different key codes in a key can be selectively combined. For example, if the lock has four lock codes, 12, 45, 79, 63, we can disable any one or any two codes, leaving a combination of three codes or two codes. If we disable the first and fourth codes (i.e. 12 and 63) of a lock, then it has a combined code 4579, (for convenient sake, this combination of code is hereinafter referred to as "partial combined code") and can be unlocked by a key of which the second and third codes are 45 and 79. (Here the first and fourth key-codes do not affect the unlocking of the lock with the like "partial combined code"). Likewise, we can also disable the third code of the lock, giving it a partial combined code 124563. Then the lock can be unlocked by a key of which the first, second and fourth codes are 12, 45, 63. (Here the first lock code is not essential either). Thus the user can use a key having four key codes 12, 45, 79, 63 to respectively unlock the two locks of partial combined codes 4579 and 124563. For a lock having n lock-codes, there are $2^n - 1$ possible combinations. This means using a lock of, for example 4 key-codes, one can unlock 15 different locks of different codes. Thus one only need to hold a single key.

According to still a further feature of this invention, both the key and the lock are provided with code-setting means to set or change the key-codes and lock-codes. Thus when the user forgets to carry his key with him or loses the key, he can borrow a card-key from other person or buy a new card key and switch its key-code to correspond to the lock-code of the locks of his own property (for example, a car, or a house etc.). Hence he can easily enter his car or house without calling a locksmith.

According to still a further feature of this invention, the lock-code in a lock can be set or changed by adjusting the key-code setting means of a card key inserted into the lock, then the lock-code setting means in the lock will be actuated and the lock-code will be correspondingly changed. (This case is somewhat like that when one changes the code of a combination lock of a suitcase.)

Practically, the key-code and the lock-code are given by setting a plurality of switch units. The ON/OFF state of a switch unit gives a high/low result. Therefore the resulting code is a binary number. In the aforesaid example we use decimal numbers (12, 45, 79, 63) only for convenients sake.

The key-code and the lock-code depend on the states of the switch units of the code-changing means. The states of the switch units of the card key and the lock must be converted into electrical signals so that

they can be compared by a comparator. For this purpose, there is provided a key-code encoder which converts the states of the switch units of the key-code-setting means into an electrical key-code signal, and a lock-code encoder which converts the states of the switch units of the lock-code-setting means into an electrical lock-code signal. The key-code signal and the lock-code signals are inputted into a comparator to check if they coincide with each other. The lock-code encoder is provided in the control circuit, whereas the key-code encoder can be provided either in the card-key or in the control circuit.

In order to enable the user to change the lock-code by adjusting the key-code-setting means, the lock has two modes, namely "read mode" and "write mode". In the "read mode", when the key is inserted into the lock, the control circuit will "read" its key-code, and compare it with the lock code. In the "write mode", when the key is inserted into the lock, if the user changes the key-code by adjusting the key-code changing means the lock-code will correspondingly change. For this purpose, the control circuit has a manually operated mode-selector switch to select the mode of the lock.

This invention will become apparent when read in connection with the accompanying drawings, in which:

Fig. 1A is a brief block diagram of the circuit of

the card key and the control circuit of the lock, in which the key-code encoder is incorporated in the card-key;

Fig. 1B is a brief block diagram showing another embodiment of this invention, in which the key-code encoder is incorporated in the control circuit;

Fig. 2 is a detailed block diagram of the card key of Fig. 1A;

Fig. 3 is a detailed block diagram of the control circuit of Fig. 1A; and

Fig. 4 is a flowchart showing the unlocking of the lock when a predetermined number N of allowance of failure of trial is offered.

Referring to Fig. 1A, this invention comprises two main parts, namely a card key 1 and a control circuit 5 for the lock. The former is integrated in a portable card (not shown), whereas the latter is incorporated in a lock to control the locking and unlocking thereof. The card key 1 has a connector 4, which corresponds to the connector 4a of the control circuit 5. Thus when the card key 1 is inserted into the lock, the circuit of the key and the circuit 5 are combined to form a single circuit. The control circuit 5 has its own power supply (not shown). Though the card key is not provided with its own power supply, when it is inserted into the lock, it can be energized by the power supply of the latter. The key-code is set in the key-code setting switch 2. The lock-code is set in the lock-

code setting switch 2a. The key-code and the lock-code (i.e. the states of the setting switches 2 and 2a) are respectively encoded by encoders 3 and 3a into signals discriminable by a comparator 53 and the signals are sent to the comparator 53 to check whether or not the key-code and the lock-code are coincident with each other. If the two codes coincide with each other, the unlocking circuit 56 is actuated to unlock the lock. If this is not the case, the unlocking circuit 56 cannot be opened. If necessary, an alarm can be actuated (not shown). An error detecting circuit 57 is provided to detect the inconsistency of the key-code to the lock-code. If an inconsistent state is perceived, the error detecting circuit 57 will actuate the alarm.

The key-code in the circuit 1 can be changed by pushing the push buttons or other proper known means (not shown) provided on the card key which changes the state of the key-code setting switch 2. Likewise, the lock-code in the control circuit 5 can also be changed by pushing the push buttons or other proper known means (not shown) provided on the lock to change the state of the lock-code setting switch 2a. Of course, the push buttons of the lock must not be accessible from outside, (for example from outside of a car or a door), but from inside to permit only authorized personnel to access them.

If the user changes the lock-code and forgets to correspondingly change the key-code (or reversely, changes the key-code while forgetting to correspondingly change the lock-code), the key-code and lock-code will be inconsistent and the lock cannot be unlocked when the card key is inserted therein. In order to allow the user to change the key-code to match the lock-code, the alarm is not immediately actuated at the failure of the first attempt to unlock the lock. So the user can still try a few times (for example, four times) by changing the key-code, until the allowable predetermined number of failures is over. The number of allowable failures N (for example, four) is predetermined in the counter circuit 52. If one fails to unlock the key before the predetermined allowable number is over, the whole system will be blocked, and the error detecting circuit 57 will actuate the alarm.

In order to enable the user to use a single card key to unlock several different locks, the setting switch 2 may comprises a plurality of setting switch groups 21 to 24. Each of the setting switch groups 21 to 24 can set a key-code corresponding to a lock-code of a lock. For a given lock, only the signal of the key code of the a given setting switch group, for example 21, is allowed to pass to reach the unlocking circuit 56, while the signal of the remaining three groups 22, 23, 24 are blocked. To enable the result of

the comparison signals of the four groups 21 to 24 to selectively pass to the unlocking circuit 56, there is provided a logic gate 55 which only allows the result of the comparison with the signal of the selected group to pass through. The selection is made by a group selector switch 54. The user can set the state of the group selector switch 54 to decide the signals of the groups which are allowed to pass through.

To enable all four codes of setting switch groups 21 to 24 to combine into a single complicated code (total combined-code), the lock-code setting switch 2a may comprise four lock-code setting switch groups 21a, 22a, 23a and 24a, in each of which a lock-code can be set. For example, if the key-codes in key-code setting switch groups 21, 22, 23, 24 are respectively 12, 45, 79 and 63, the total combined key-code is 12457963. The lock-codes in the four lock-code setting switch groups 21a, 22a, 23a and 24a must also be 12, 45, 79 and 63. Then the group selector switch must be so set to allow all the signals of the four groups to pass.

However, one generally does not use the single complicated code in the lock in practice. In most cases, we use a single key to unlock several different locks. In the latter's case, only one out the four lock-codes in the four lock-code setting switch group of lock-code setting switch 2a is essential. Though all four lock-codes are compared with the four key-

codes in the comparator 53, only the result of comparison of one specific key-code and lock-code can reach the unlocking circuit 56 if the unit selector switch 54 is so set as to allow only the result of the comparison of signals of a given group to pass through. For example, suppose the group selector switch 54 is set to allow the signal of the first group to pass through, if the lock-code in the first group 21a of setting switch 2a is 12, then the lock can be unlocked, regardless of whether or not the lock-codes in the remaining three groups 22a, 23a and 24a are coincident with the key-codes in groups 22, 23 and 24, since the signal of the result of comparison of the three groups cannot pass through logic gate 55.

As stated before, to change the lock-code, the user can either directly adjust the switch units in the lock-code setting switch 2a, or alternatively set the desired lock-code by means of the key-code setting switch 2 when the key is inserted in the lock. For this purpose a mode selector 6 is provided. The mode selector has a toggle switch 61 which can be manually operated to select the mode of the lock. The lock has two modes, namely "read mode" and "write mode". In the read mode the signal of the key-code is sent to the comparator 53 to make comparison with the lock-code. In the write mode, the signal of the key-code is sent via the mode selector 6 to the lock-code setting switch 2a to change the states of the switch units therein to

correspond to the states of the switch units in the key-code setting switch 2. Thus, if the user wants to change the lock-code by means of the key-code setting switch 2, he can switch the toggle switch 61 of the mode selector 6 to the "write mode" and then insert the key into the lock and readjust the switch units in the key-code setting switch 2. In so doing, the lock-code is changed. To allow the lock-code to be adjusted by the key-code setting switch 2 in the write mode, the encoder 3a must be provided with a memory and a software to carry out this function. Like the lock-code setting switch 2a, the toggle switch 61 is also only accessible from the inside of the door of the lock so that only authorized personnel can access it.

As stated before, the user is allowed to try a predetermined number of times N to readjust the key-code. Please refer to the flowchart in Fig. 4. If the key-code does not coincide with the lock-code, the user can take out the key from the keyhole and re-adjust the key-code, and then re-insert it into the key hole. If the predetermined number of times N is over, and the key-code still doesn't coincide with lock-code, the whole system will be blocked, and an alarm signal is produced. After a predetermined period (say three minutes), the alarm signal will stop and the blockage of the system is released, so the state of the system returns to normal.

In the embodiment of Fig. 1B, the encoder 3 for the key-code is not incorporated in the card-key 1, but in the control circuit 5. Since the card-key does not contain the encoder 3 its size can be further reduced and becomes more portable.

The main function of the block diagram in Fig. 1A has been explained. In the following, the details of the circuit in Fig. 1A will be mentioned. It is noteworthy that the detailed circuit is only an illustrative embodiment, and not restrictive per se.

Referring to Fig. 2, each of the four setting switch groups 21 - 24 comprises ten separate switch units. Encoder 3 comprises five data selectors 31 to 35. Thus the ON/OFF state of the individual switches in each setting switch groups 21 to 24 can be encoded into a corresponding signal discirminable by the comparator 53. Each of the key-code setting switch groups 21 to 24 has outputs which are connected to the input of the first selector 31. Each of selectors 31 to 35 has two outputs which are connected to the ten terminals 41 of connector 4.

Connector 4 has 15 terminals 41, 42, 43, 44, 45, and 46 which corresponds to the 15 terminals of connector 4a, namely 41a, 42a, 43a, 44a, 45a and 46a.

The ten terminals 41 are used for the output of the key-code. They are connected to comparator 53. Terminals 45, 46 are power terminals and connected together. The four terminals 42, 43, 45 and 46 are

connected to timer 51. Terminal 44a (and also terminal 44) is grounded.

The comparator 53 comprises a logic circuit 531 formed by a number of logic gates, and a shift register 532. The structure of key-code setting switch 2a and encoder 3a are similar to that of key-code setting switch 2 and encoder 3. The details of the above few paragraphs are all known techniques, and further explanation is not necessary. Like encoder 3, the encoder 3a also has ten outputs respectively connected to the ten XOR gates of comparator 53, thus the ten signals from encoder 3a are respectively compared with the signals from encoder 3. Unlike terminals 45, 46, the terminals 45a, 46a are not connected together. Terminal 45a is connected to the timer 51. In the timer 51, a transister 513 serves as the controlling element. The timer 51 is also provided with a pulse generator 511 and a counter 512. The latter 512 has two outputs connected to the selecting terminals 42a, 43a. When the transistor 513 is actuated, the output signal can be sent to the two terminals 42a, 43a.

The counter circuit 52 allows the user to commit a predetermined number N of errors before he successfully unlocks the lock. It comprises a pulse generator 521 and two counters 522, 523. When the number of errors exceeds the predetermined value N, the counter circuit 52 will send a signal to the timer 51 to stop its

timing. Thus the timer 51 no longer sends signals to the selecting terminals 42a, 43a. The logic gate 55 is connected to the unlocking switch 56. This logic gate 55 is controlled by group selector switch 54. Group selector switch 54 must be properly adjusted with respect to the setting switch 2a.

In use, the user can preset the lock-code in the lock by the setting switch 2a. When the card key 1 is inserted into the lock, since the two setting terminals 45, 46 are connected together, the terminals 46a, 45a are conductive. Thus the positive electricity can be supplied to timer 51, which in turn produces two signals which are supplied through the two selecting terminals 42a, 43a to the selectors 31 to 35. In so doing, the output signals can be sent to the comparator 53 to make comparison.

In this embodiment, each of the groups 21 to 24 has ten switches, thus each group has 1024 possible states. The security against burglars is very high. If desired, the state of the switches in the units 21 to 24 can also be unadjustably fixed.

The mode selector 6 is an ON/OFF switch, and can be operated by a manually operated toggle switch 61. In the "read mode", the mode selector 6 is in the OFF state, so the signals from the card-key 4a are sent to the comparator. In the "write mode", the mode selector 6 is in the ON state, and the signals from the card key 1 will be tapped through mode selector 6 to the lock-

code encoder 3a to change the state of the lock-code setting switch 2a.

The blocks 3a, 51, 52, 53, 6 can be integrated in a signal chip (In Figs. 1A and 2B, the integrable part is enclosed in the zone defined by the broken line.). If the lock-code setting switch 2a is not desired to be manually adjusted, it can also be integrated into the chip. This can greatly miniaturize the size of the control circuit.

The detailed wiring of the second embodiment in Fig. 1B is similar to that of Fig. 1A, thus it is not necessary to make specific illustration for its details.

The card key is not necessarily in the form of a card. It can also be in another form corresponding to the shape of the keyway of the lock.

The advantages of this invention are manifold. Firstly, the user only needs to keep a single key for a great many locks. He need not bother himself by seeking the correct key out of a battery of keys. Nor does he need to memorize which key corresponds to which lock. This advantage is especially apparent for hotel administrators who can take care of one thousand rooms using a single common key having ten key codes. (An occupant of a room cannot use his room key to unlock other occupant's room since his key is provide with only at most nine key codes and can only unlock his own

room.) This advantage can also be seen in other examples. In case Mr. A urgently wants to enter Mr. B's house, and Mr. B happens to be far away (for example, abroad), Mr. A only need to telephone Mr. B and ask the key-code of Mr. B's house, and then set this key-code in his own card key, then he can easily enter Mr. B's house.

Secondly, the user need not memorize the code of the lock, as it is necessary in the case of conventional combination locks. Since after selling, the codes are stored in the key and lock, the user only needs to simply insert the key into the lock, and it's O.K.

Thirdly, the security of the lock is extremely high. Suppose each code is set by ten switches, then a code has $2^{10}=1024$ possibilities. Suppose a lock has n such codes, then there are 10^n switches, so the possible combination is 2^{10n}. Pratically n is chosen as four, so there are more than 10^{12} possibilities. Thus an unauthorized person would have little chance to unlock the lock.

CLAIMS:

1. A control circuit for a lock and a key for unlocking said lock, said lock comprising unlocking means to unlock said lock, said control circuit comprising a connector, at least a lock-code setting means in which a lock-code is stored, a comparator, and an unlocking switch for actuating said unlocking means, said key comprising a connector to connect with the connector of said control circuit, and at least a key-code setting means in which a key-code is stored, said control circuit and said key being such that when said key is inserted into said lock, said key and said lock are electrically connected and said comparator compares said key-code and said lock-code, and only when said lock-code and said key-code coincide with each other can the comparator actuate said unlocking switch to actuate said unlocking means.

2. The key and control circuit according to Claim 1, wherein said key-code setting means and said lock-code comprise a plurality of switch units of which the state decides said key-code and said lock-code, each of said switch units being switchable between an ON and an OFF state.

3. The key and control circuit according to Claim 2, further comprising a key-code encoder for converting the state of the switch units of said key-code setting

means into a signal acceptable by said comprator and a lock-code encoder for converting the state of the switch units of said lock-code setting means into a signal acceptable by said comparator.

4. The key and control circuit according to Claim 1, wherein said key comprises a plurality of key-code setting means, each having a key-code corresponding to the lock-code of a lock.

5. The key and control circuit according to Claim 1, wherein said key has n key-code setting means, and said control circuit has n lock-code setting means, where n is a positive integer greater than 1.

6. The control circuit according to Claim 5, wherein at least one out of the n lock-code setting means is disabled.

7. The key according to Claim 5, wherein at least one out of the n key-code setting means is disabled.

8. The control circuit according to Claim 1, further comprising a mode selector for selectively switching said control circuit between a first state in which the signals from said key is sent to said comparator for comparison with said lock-code, and a second state in which the signal from said key is sent through said mode selector to said lock-code setting means to change the lock-code corresponding to said key-code.

9. The control circuit according to Claim 8, wherein said lock-code encoder further comprising a software which changes the lock-code in said lock-code setting means to correspond to said key-code when said control circuit is in said second state.

10. The control circuit according Claim 4, further comprising selecting means to allow only the result of comparison of selected lock-codes of said n lock-code setting means with said key codes to reach said unlocking switch.

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